Some Recent Research Results on Non-Lethal Means of Reducing Animal Damage to Reforestation Projects in the Western United States

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Abstract

Research results on non-lethal methods from a collection of recent studies are described for reducing damage to seedlings inflicted by pocket gophers, mountain beavers and deer. Methods include the use of mechanical barriers, repellents, and vegetative manipulation. Long-term studies on the use of plastic mesh cylinders demonstrated substantially decreased pocket gopher damage, and increased seedling survival and growth. Tests on a variety of candidate repellents produced a wide range of results, with putrescent materials and thiram providing good protection and predator urines showing promise if application methods can be improved. Herbicide control on pocket gopher habitat yielded long-term reductions in damage rates and higher survival rates than untreated sites.

Introduction

Reforestation efforts in the western United States are challenged by numerous wildlife damage problems. Mammals from elk and black bear to small rodents damage seed, seedlings and maturing trees (eg Campbell and Evans 1984, Campbell 1992). Lethal treatments often cannot be applied or may produce only temporary population reduction. Meanwhile, there is an increasing interest in the use of non-lethal means to reduce animal damage (Acord 1992). This paper summarizes some recent research results on non-lethal methods for reducing animal damage to seedlings by three animals largely responsible for damage to seedlings in the western United States; pocket gophers (*Thomomys spp*), mountain beavers (*Aplodontia rufa*), and mule deer (*Odocoileus hemionus*).

Stand establishment is hindered by the cutting and gnawing of seedlings by mountain beaver and pocket gophers and browsing by deer. Girdling of older trees by foraging animals also causes substantial mortality or subjects trees to disease and insect infestations. Newly planted and pre-commercially thinned stands are the most vulnerable to damage. Loss of trees to damage often causes stands to become understocked or suffer suppressed height growth rates. Trees can lose five to ten or more years of height growth, adversely affecting final timber yield.

Pocket gopher barriers

Plastic mesh barriers, originally used to discourage browsing on seedlings by ungulates, have successfully reduced damage by pocket gophers (eg Anthony *et al.* 1978). To obtain additional information, we conducted long-term wide-scale tests of plastic mesh tubes in California, Oregon and Idaho. Sites were selected for past histories of reforestation failure due to gophers, uniformity of gopher distribution and homogeneity of vegetative composition and distribution. At each site, 640 protected and 640 control seedlings were planted (3840 total), and individually monitored for damage, survival and growth for five years. Substantial protection from gopher damage was demonstrated (Table 1).

Table 1. Protected (P) and control (C) seedlings in three states that suffered damage, gopher caused mortality, and mortality from all causes.

	California		Oregan		Idaho	
	C(%)	P(%)	C(%)	P(%)	C(%)	P(%)
Damaged	57	25	60	18	89	27
Mortality by gophers	54	19	46	2	64	1
Mortality, all causes	76	52	63	19	68	5

The rates at which seedlings were damaged by gophers were substantially greater for controls than protected seedlings at each site. Damage inflicted on protected seedlings was less likely to be fatal. Overall survival was much greater for protected seedlings, primarily due to fewer gopher attacks, but also may be attributed to an improved microclimate inside the tubes (Borrecco 1976), as indicated by greater growth for undamaged, protected seedlings than for undamaged, unprotected seedlings. We are currently investigating a variety of barrier materials on the basis of efficacy, cost, and environmental effect.

Repellency tests

Repellents deter foraging animals by decreasing the palatability to the protected forage. Herbivory is generally restricted in the presence of decomposing proteins. This avoidance may be a response to volatile sulfur compounds (Mason *et al.* 1994). We tested the repellency of several sulfur containing compounds. Big Game Repellent Powder (BGR-P), a registered ungulate repellent containing 36% inedible egg solids, was investigated for efficacy in reducing mountain beaver damage. Efficacy of a powder made from processed starlings (Sturnus vulgaris) to deter deer and mountain beaver damage was also tested. In addition, we investigated the efficacy of coyote and mink urine to reduce food intake by mountain beaver in pen trials. Predator odours are generally aversive to prey (Epple *et al.* 1993) with avoidance mediated by urinary constituents. Additional test were conducted on the efficacy of thiram as a mountain beaver repellent, and garlic oil marketed in clip-on capsules as a deer repellent.

Bitter substances are generally regarded as unpalatable (Garcia and Harkins 1975). Many naturally occurring bitter compounds are associated with toxic effects, which has encouraged the supposition that all animals avoid bitter taste. We tested products that contain extremely bitter compounds. Denatonium saccharide was applied topically to seedlings to measure deer responses. Pocket gopher responses were tested with systemic applications of denatonium benzoate to seedlings, while mountain beaver responses were tested by a topical application of denatonium benzoate.

After finding no systemic efficacy for selenium, we tested topical applications of sodium selenite (Na_2SeO_3) in two bacterial formulations, *Corynebacterium spp.* and *Pseudomonas fluorecens*, under the presumption that metabolic decomposition of sodium selenite by the bacteria would produce dimethyl selenite, and this would repel deer.

A wide range of efficacies resulted among tested substances (Table 2).

Table 2. Percent of seedlings damaged in repellency experiments[1].

Test Substance	Test Species	Test Site	Exposure Time	Seedlings Damaged	
				Control(%)	Treated (%)
BGR-P	MB	Pen	1 mo	100	17
BGR-P	MB	Field	7 mo	53	21
BGR-P	MB	Field	4 mo	88	1
BGR-P	MB	Field	4 mo	81	8
Starlings	MB	Pen	2 mo	81	13
Starlings	D	Pen	2 mo	66	0
Starlings	D	Pen	2 mo	83	8
Coyote Urine	MB	Pen	2 wks	68	10
Mink Urine	MB	Pen	2 wks	68	7
Thiram	MB	Field	8 mo	94	17
Garlic Oil	D	Pen	2 days	100	100
DB-systemic	PG	Field	12 mo	44	38
DB-topical	MB	Pen	2 wks	68	50
DS	D	Pen	1 mo	82	88
Na_2SeO_3/CB	D	Pen	2 wks	63	8
Na_2SeO_3/PF	D	Pen	2 wks	63	0

[1]Abbreviations are: Species, D=deer, MB=mountain beaver, PG=pocket gopher. Test substance: DB=denatonium benzoate, DS=denatonium saccharide, CB=Corynebacterium, PF=Pseudomonas fluorecens.

BGR-P effectively deterred mountain beaver up to six months. Starling powder reduced damage by mountain beavers and deer similar to that induced by BGR-P treatments. Prior experience with either of these substances appeared to enhance later repellency. Thiram (21% concentration) was effective at inhibiting foraging by mountain beaver for an extended period of time. Deer extensively browsed seedlings treated with the garlic product (Nolte *et al.* 1995). Predator urines deterred mountain beaver from foraging on seedlings, and some preliminary results indicate the same for deer. However, the volatility of aversive urine constituents makes it necessary for an improved delivery system to be developed before these products can serve as effective long-term repellents. Predator urines are among the few compounds which demonstrated efficacy to deter pocket gophers during screening trials. Regardless of application method, the bitter compounds were ineffective to protect seedlings by any of the animals tested. This data corresponds well with the hypothesis that compounds tasting bitter to humans are not aversive to herbivores (Jacobs *et al.* 1978, Nolte *et al.* 1994). Short-term deterrence to browsing was exhibited by the selenium salts/bacterial culture formulations. We have been investigating other aspects of repellency including the use of visual cues in combination with repellents and the efficacies of native and exotic plants with irritating or toxic characteristics.

Vegetative management

Clearing of forests by cutting or fire encourages the growth of successional vegetation which supports large pocket gopher populations. Herbicide application has been investigated to control gopher populations by reducing their forage resources. We conducted two studies in Oregon on sites with long histories of regeneration failures due to gopher damage. Atrazine was applied at the Cavc Mountain site, whereas 2,4-D was applied at the Dugout Lake site. Seedlings were individually monitored for two to four years for damage and survival. Each site yielded promising results (Table 3).

Table 3. Percentage of undamaged seedlings in control and herbicide-treated cohorts at two sites.

Seedling Cohort	Years Followed	Damaged	
		Control (%)	Treated (%)
Cave Mountain 1	4.3	100	66
Cave Mountain 2	2.3	71	37
Dugout Lake	2.5	91	49

These test sites represented extreme gopher damage situations. Seedlings planted on sites with either of the herbicide treatments received substantially less damage, without the need for one or more annual treatments as is often needed for lethal control efforts. Reduced gopher activity during the initial post-planting years may enable seedlings to grow beyond the most vulnerable stages before high pocket gopher populations become established. At present, we are evaluating whether the same effect can be achieved by grazing livestock.

Discussion

Reforestation efforts in the United States are hampered by damage inflicted by a variety of wildlife species over a long production period. Traditional damage reduction methods have focused on reducing populations of offending species. However, the expense and rapid post-treatment invasion by conspecifics often makes lethal methods ineffective. Non-lethal measures may provide feasible alternatives.

Recent results from several lines of investigation are promising, including those presented here. New materials and methods are needed along with refinement of current methods. Ideally, long-range studies could identify the relationships of animal population processes to damage and produce a foundation that would enhance our ability to predict damage levels and generate the appropriate responses. An holistic treatment of animal damage problems involving integrated pest management is needed to successfully protect our forest production.

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